Punnett L. Ergonomic stressors and upper extremity disorders in vehicle manufacturing: cross-sectional exposure-response trends. Occup Environ Med 1998;55:414-420.

Design: Workplace-based cross-sectional survey

Population/sample size/setting:

- 1315 hourly auto workers (1076 men, 239 women, mean age 47) in Detroit, either at a vehicle stamping plant (n=694) or an engine assembly plant (n=621)
- 1550 workers were invited to participate in an interview and physical exam of the musculoskeletal system
- Based on company records and a pilot study, workers with high exposures to suspected ergonomic risk factors for upper extremity disorders were selected, together with workers thought to have non-routine jobs with low exposures to these suspected ergonomic factors

Main outcome measures:

- 1198 workers had adequate data quality for analysis, after exclusion of 117 who were not in production or had poor data quality
- All workers were interviewed and examined in the same working day
- Standardized interview had data on work history (exposure to non-neutral postures, work pace, vibration, manual forces to handle tools and parts, mechanical pressures from hand held tools), as well as past medical/surgical history, musculoskeletal symptoms in the past year, BMI, alcohol & tobacco use, sports, and hobbies
- Current upper extremity symptoms were elicited at the same interview: onset, frequency, duration, location, medical treatment undertaken, etc
- Structured physical examinations (PE) were done on all subjects, including active and passive range of motion, Phalen and Finkelstein tests, sensory vibration thresholds, and grip and pinch strength by dynamometer
- Two case definitions were used: symptom cases had pain with onset in the past 12 months which had begun after their date of hire, had occurred at least 12 times, or were continuous for the past year; PE cases had one or more physical findings together with symptoms in the corresponding body part beginning after their date of hire
- In addition to the interview, exposure information was gathered by observation: workstation dimensions, tool weights, production and work cycle data, and flexion/extension of wrist, elbow, shoulder, and trunk; observations were done without knowledge of the worker's health status
- The exposure items on the interview and PE were scored individually and then added to a single summary score; the scale for the interview was from 0 to 25, and for the observations of exposure the scale was from 0 to 22
- There was a strong trend in the data between exposure scores and health status; the highest quartile of ergonomic exposure had more than twice the

prevalence of upper extremity cases (data shown graphically and not reported numerically); this trend was true for both symptom cases and PE cases
- When this trend was adjusted for potential confounders (such as acute injury, sex, systemic disease, age, BMI, and recreational activities), the trend remained undisturbed, suggesting that these variables were not confounders

Authors' conclusions:
- An exposure score derived from a structured interview was a powerful predictor of the risk of musculoskeletal disorders of the upper extremities
- The prevalence of upper extremity disorders increased markedly with exposure to ergonomic stressors
- Such an exposure scoring tool could facilitate the rapid identification of workers with high exposures who might benefit from early intervention
- The exposure scoring system could also identify high risk jobs for hazard surveillance

Comments:
- Diverse kinds of exposure, for the purposes of statistical analysis, were combined into a single summary score
- While this strategy is useful in being able to identify trends between exposure and upper extremity disorders, it tends to obscure the contribution of the individual factors
- The exposures were originally recorded on the 10 point Borg CR10 scale, which is a subjective assessment of how intense an effortful activity is; it is not translatable into units of cycles per minute or kilograms
- Thus, the results are more qualitative than quantitative; it is shown that being in the highest quartile of a manufacturing plant is associated with an increased probability of being a "case," but the number of kilograms or cycles per second is not clear for the reasons stated above
- Symptom cases and PE cases are not specific diagnoses, and it is likely that higher exposure levels would be required to produce diagnosable disorders than would be required to produce symptoms
- Proportional hazards regression (like logistic and least-squares regression) assumes a monotonic incremental relationship between an exposure and an outcome, such that zero exposure is best, some is bad, and more is worse
- This kind of analysis makes sense for many exposures in occupational epidemiology: benzene fumes, methyl mercury, plutonium, gamma radiation, etc, where zero exposure is considered optimum
- When the "exposure" is using the limbs to do things, this assumption of linearity makes no sense; it is biologically implausible that zero exposure is optimum
- Most of the available literature makes this assumption of linearity
- If there is a nonlinear relationship between exposure and musculoskeletal disorders, it is likely to be detected by entering a quadratic term in the regression model, and seeing whether this improves the fit of the model to the data

- The exposure-disease relationship remains unclear with this analysis
- Because vehicle manufacturing is likely to be paced work, it is probable that the exposures of interest were present for at least 6 hours per working day

Assessment: Adequate only for a qualitative statement that ergonomic stressors are risk factors for upper extremity musculoskeletal disorders